(12) UK Patent Application (19) GB (11) 2 385 478 (13) A

(43) Date of A Publication 20.08.2003

(21) Application No 0228402.4

(22) Date of Filing 05.12.2002

(30) Priority Data
(31) PR9672 (32) 20.12.2001 (33) AU

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(51) INT CL[7]
G01F 23/284 , H01P 3/06

(52) UK CL (Edition V)
H4D DRPG D352 D399

(56) Documents Cited
GB 1314368 A WO 2001/063219 A
US 5742002 A US 3695107 A
WPI accession no 1996-138368 [14] & RU2040081 C1

(58) Field of Search
UK CL (Edition V) H1A, H1W, H4D
INT CL[7] G01F, H01B, H01P
Other: Online: WPI, EPODOC, PAJ

Search more IPC classes

(54) Abstract Title
Probe for liquid level sensor

(57) A probe 12 for a radar liquid level sensor includes an elongate waveguide 16 defining a central bore, a central conductor 18 disposed in the bore and extending substantially the entire length of the bore. The central conductor is maintained in spaced relation to the wave guide by an elongate spacer 20 positioned between the waveguide and the central conductor 18. Spacer 20 does not need discontinuities in the aerial or waveguide in order to keep it in place, and may be fixed by friction or adhesive. Spacer 20 may have three lobes 21 and may be made of plastic.

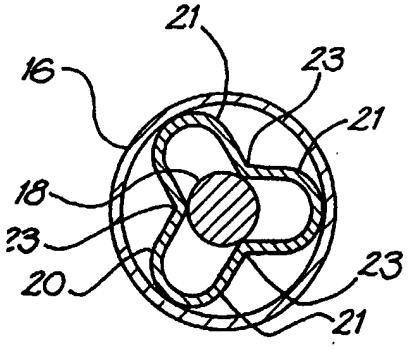

FIG. 2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

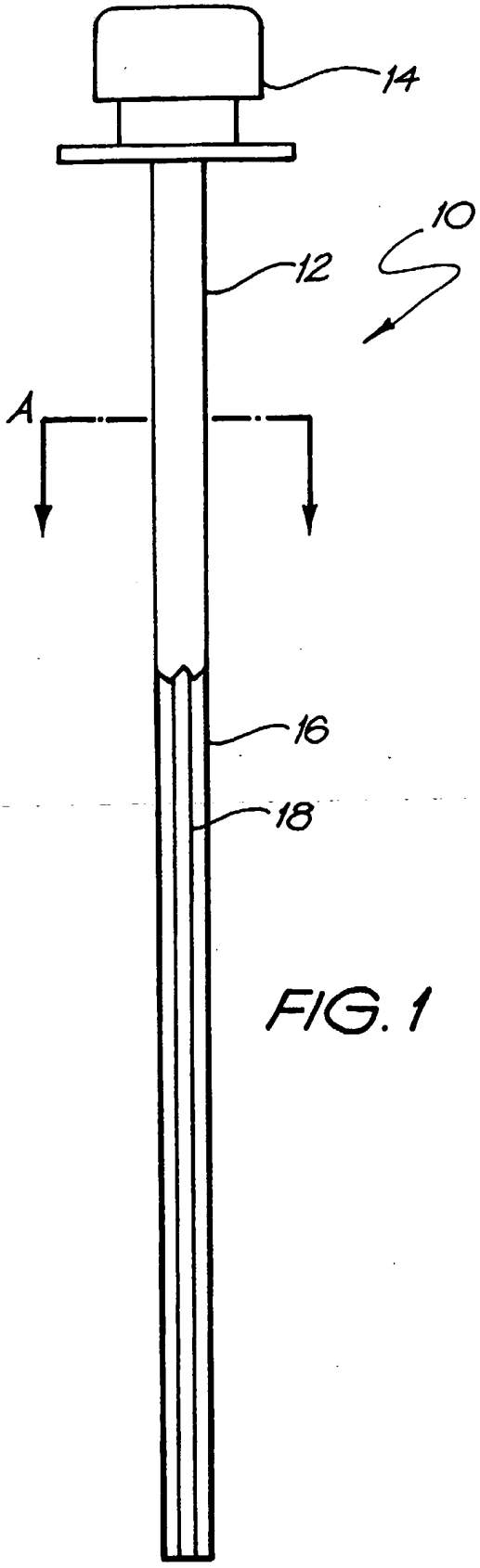

FIG. 1

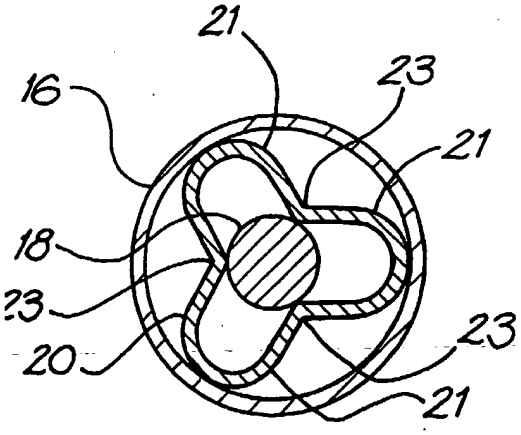

FIG. 2

A PROBE FOR A RADAR LIQUID LEVEL SENSOR

Technical Field

This invention relates to probes for use in radar liquid level sensors.

Background to the Invention

One application of "radar" (Radio Detection and Ranging) technology is for sensing the liquid level in containers and tanks. Some have tried mounting a conventional radar transceiver in the roof of a tank, transmitting signals downwards in a relatively wide cone, and detecting and analysing the signals reflected by the liquid surface. However, stray reflections from protuberances in the tank produce false echoes which interfere with the operation of these devices. Further, there is a large loss of signal through dispersion and absorption requiring the use of a relatively high powered radar transceiver.

To address the above problem, some have used guided wave radar. A probe is formed from an elongate inner aerial encased in a surrounding wave guide in the form of an elongate tube. The aerial is spaced from the inner wall of the waveguide. In use, this probe extends the full depth of the tank in which a liquid level is to be detected. A radar transceiver is mounted at the upper end of the probe in communication with the inner aerial. Signals emitted by the transceiver are contained in the annulus formed between the aerial and the waveguide. Thus, the received signal does not suffer from signal dispersion or false echoes from tank protuberances.

In operation, the radar transceiver emits a series of pulse signals, typically around 200 pulses per second. When the pulses meet a discontinuity, such as a change in impedance due to a dielectric change, a reflection is developed. An engineered impedance change is developed in the top of the liquid level sensor to generate a fiducial pulse, or baseline reflection. Another reflection is developed at the surface of the liquid level being measured, the primary level reflection. When the primary level reflection is detected, the time difference between it and the fiducial reflection is obtained, allowing the level of the liquid to be calculated.

In the above guided wave radar probe, the inner aerial must be maintained substantially centrally within the outer waveguide. This improves the uniformity of the transmission signal. Further, and particularly in the case of mobile applications such as road tankers, the aerial must be supported against shock and vibration. This has been done by inserting steadying "spiders" at regular spacings in the annulus. These spiders abut both the inner aerial and the surrounding tube to brace the inner aerial away from the inner wall of the outer tube. Some have attempted affixing these spiders with adhesive. However, contact with chemical agents and temperature fluctuations can weaken the adhesive leading to a high failure rate. As a consequence, the spiders are typically located by sitting in a groove, or engaging with holes, machined in the aerial or surrounding waveguide. However, these machined holes or grooves, and the spiders themselves, produce false echoes which tend to nullify the originally sought advantages. It is an aim of the present invention to improve on this problem.

Summary of the Invention

According to a first aspect the present invention provides a probe for a radar liquid level sensor including an elongate waveguide defining a central bore; a radar aerial disposed in the bore and extending substantially the entire length of the bore; the aerial is maintained in spaced relation to the wave guide by an elongate spacer positioned between the wave guide and the aerial; and retaining means for retaining the spacer in the probe wherein the retaining means does not include discontinuities in the aerial or waveguide. The absence of discontinuities in the aerial or waveguide, such as holes or grooves, eliminates the possibility that the operation of the probe will be hindered by false echoes produced by such discontinuities.

Preferably, the retaining means includes the abutment of the spacer against the wall of a vessel in which the probe is mounted. In most cases, the spacer is arranged to abut the bottom surface of a tank or the like. This provides a simple yet effective way of retaining the spacer in the probe.

Alternatively or additionally, the retaining means can include an interference fit between the spacer and the waveguide or aerial. This resists the spacer from becoming disengaged from the probe prior to installation.

Alternatively or additionally, the retaining means can include adhesive. This provides added resistance against disengagement of the spacer.

Preferably, the spacer extends substantially along the entire length of the aerial. In this way, the spacer does not present an end surface to reflect signals travelling down the waveguide.

Preferably, the spacer surrounds the inner aerial for substantially the entire length of the spacer.

Preferably, the spacer includes at least one longitudinal lobe. This lobe serves to maintain the inner aerial in spaced relation to the waveguide.

Preferably, the spacer includes three substantially equidistantly spaced longitudinal lobes. A spacer of this formation is effective in operation, while being of simple construction.

Preferably, the spacer is formed from a material having a low dielectric value such as plastic. Use of a low dielectric material minimises the impact of the spacer in terms of diminishing the signal strength within the probe. Plastics have a low dielectric value and are easy to work with. Further, they are inert to a wide range of reactants and thus are suitable for use in hazardous chemical environments.

Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an elevation view with partial cutaway of a liquid level sensor including an embodiment of a probe according to the present invention; and

Figure 2 is a cross section of the probe of Figure 1 along line A-A.

Referring to Figures 1 and 2, a liquid level sensor 10 is shown including probe 12 with a radar transceiver 14 mounted at one end. The probe includes a wave guide 16 defining a central bore. An aerial 18 is located in the

bore and maintained in spaced relation to the wave guide by an elongate spacer 20 (see Figure 2).

The aerial 18 and waveguide 16 are metallic in order to act as transmitters. Spacer 20 is made from a material with a low dielectric value, such as plastic and is formed by extrusion. Suitable plastics include PTFE, nylon and polyethylene. These plastics are largely inert and are well suited to hostile chemical environments.

The spacer includes three equidistantly spaced longitudinal lobes 21 which abut the inner wall of the waveguide. The lobes meet at points 23 which abut the inner aerial.

The profile of the cross section of spacer 20 is illustrative of only one embodiment of the invention. A spacer of any profile which serves to maintain the waveguide and aerial in spaced relation would be suitable.

The lower end of the waveguide is open to allow fluid to flow inside. In an assembled sensor, cooperating breather holes are provided at the top end to allow for equalisation of fluid levels inside and outside the sensor.

The spacer is manufactured to be an interference fit inside the probe 12 and is simply inserted into the lower open end of waveguide 16. In use, the spacer may become loose and tend to slip downwards of the probe. However, when mounted in a tank, the spacer abuts the bottom surface of the tank, thereby retaining the spacer in the probe 12.

Optionally, adhesive may be used to retain the spacer. Again, if the adhesive bond fails in use, the spacer is retained by abutting the bottom surface of the tank in which it is mounted.

Importantly, no machining of the aerial or waveguide is required to provide grooves or holes or the like to retain the spacer. Such grooves or holes in the aerial or waveguide can give rise to unwanted echo signals which hinder the operation of the liquid level sensor.

The spacer 20 extends substantially along the entire length of the aerial 18. In this way the spacer does not present an end surface to the transmitted waves to produce a reflection.

Whilst the invention has been described with reference to a number of preferred embodiments it should be appreciated that the invention can be embodied in many other forms.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A probe for a radar liquid level sensor including:
an elongate waveguide defining a central bore;
a radar aerial disposed in the bore and extending substantially the entire length of the bore;
the aerial is maintained in spaced relation to the wave guide by an elongate spacer positioned between the waveguide and the aerial; and
retaining means for retaining the spacer in the probe wherein the retaining means does not include discontinuities in the aerial or waveguide.

2. A probe according to claim 1 wherein the retaining means includes the abutment of the spacer against the wall of a vessel in which the probe is mounted.

3. A probe according to either claim 1 or claim 2 wherein the retaining means includes an interference fit between the spacer and the waveguide or aerial.

4. A probe according to any preceding claim wherein the retaining means includes adhesive.

5. A probe according to any preceding claim wherein the spacer extends substantially along the entire length of the aerial.

6. A probe according to any preceding claim wherein the spacer surrounds the inner aerial for substantially the entire length of the spacer.

7. A probe according to any preceding claim wherein the spacer includes at least one longitudinal lobe.

8. A probe according to any preceding claim wherein the spacer includes three substantially equidistantly spaced longitudinal lobes.

9. A probe according to any preceding claim wherein the spacer is formed from a material of low dielectric value such as plastic.

10. A probe substantially as described herein with reference to the accompanying drawings.

INVESTOR IN PEOPLE

Application No: GB 0228402.4 9 **Examiner:** Dr E.P. Plummer
Claims searched: All **Date of search:** 16 June 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
A		GB1314368	Bendix
A		US3695107	Hertz
A		WO0163219 A	Cambridge Consultants
A		US5742002 A	Andrew Corp
A		WPI accession no 1996-138368 [14] & RU2040081 C1 (Domen)	

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

H4D, H1W, H1A

Worldwide search of patent documents classified in the following areas of the IPC[7]:

G01F, H01B, H01P

The following online and other databases have been used in the preparation of this search report:

Online: WPI, PAJ, EPODOC